

Agent-Supported Mission Operations Teamwork

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NASA Human Centered Computing
Task-level Review
University of Central Florida

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Team Members

- Analysis and design methods
 - Carroll Thonesbery, Kathy Johnson, David Overland, Grace Hua
- System management agents and testbed
 - Debra Schreckenghost, Land Fleming and Luis Flores
- Information assistant agents and team tools
 - Arthur Molin, Kenneth Jenks, Kevin Kusy, Dan Smith
- Team tools and mission spin-offs
 - Patrick Oliver, David Overland, Gene Peter and Kevin Taylor (DV) and Kathy Johnson (SD – SMART project for SURGEON/BME)

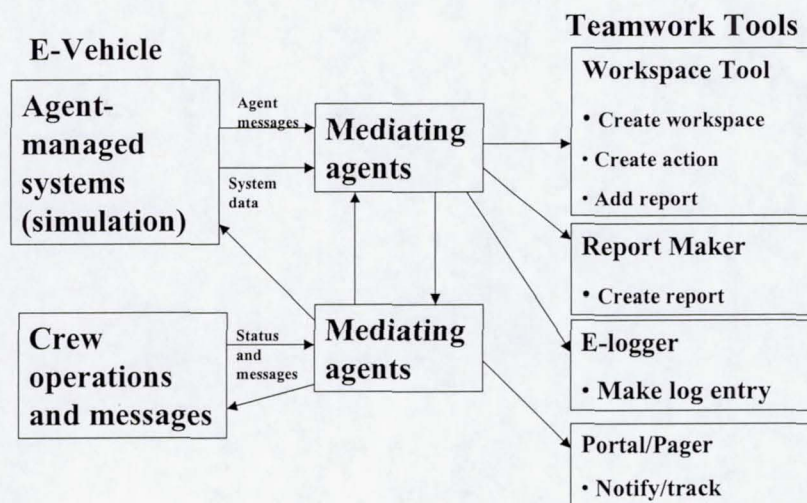
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Goals for Users

- Make automation by agents easy to use, supervise and direct
 - Smooth transitions into close supervision and intervention
- Manage information and communication to decrease distraction, interruptions, workload and errors
 - Smooth handovers across groups and shifts
- Reduce mission impact of off-nominal situations
- Increase morale and decrease turnover

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Agents and Team Tools



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Accomplishments

1. Collaborative agents - mixed initiative and creation of instructions for mediating agent
2. Methods for prototyping, evaluating and evolving socio-technical systems
3. Technology infusion: teamwork tools in missions
4. Demonstrations in simulation testbed

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1. Agents that are Team Players

- System management agents: Mixed initiative interaction
- Mediating assistants: Easy to manage

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Mixed Initiative Interaction

- Either user or agent can steer the interaction
- First step toward automation that works with the user
 - Balances both user needs and its own goals in deciding to act
 - Determines whether conditions support user-requested action
- Demonstrated: interaction to “fill out” and execute incomplete command
 - User: Execute the N₂ leak test.
 - ISMA: Now, or plan in the future?
 - User: Now
 - ISMA: OGS is shutdown and the N₂ leak test can be performed now. Should I start the test? [or, Please wait for OGS steady state]
 - User: Yes [or, No or Abort - stop interaction]
 - ISMA starts test when gets the OK. [or, ISMA aborts if test conditions change or higher priority action is needed]

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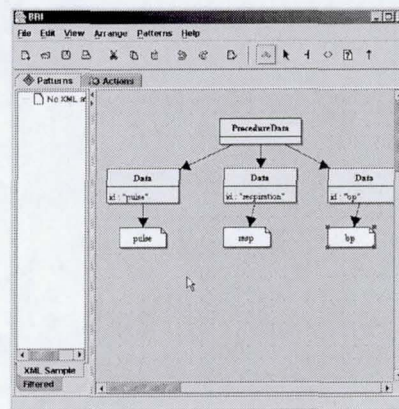
Mediating Assistants

- Information manager: Intelligent Briefing and Response Assistant
 - IBRA Engine watches data stream for triggers and executes Act-Whenever actions
 - User-defined actions can be added for a particular domain
- Users specify how IBRA should handle events with Briefing and Response Instructions
 - Triggers: Patterns to recognize when event of interest has occurred
 - Actions: What IBRA should do when event occurs
 - Collect additional data, create log entries, make reports
 - Notify appropriate people that event has occurred

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Briefing and Response Instruction (BRI) Editor

- Simple for discipline specialist to create a BRI
- Create trigger based on:
 - Previous data logs
 - Data declaration files
 - Existing BRIs
- Choose actions from palette
- Trigger and action structures can be simple or complex



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Example: Specifying Leak Test Instructions

- Set of BRIs that are activated together
 - BRIs can activate and deactivate other BRIs
 - May be loaded into a special-purpose IBRA
- Measure time to reach threshold values
- Reporting with triggered alternatives
 - If the rate of change of pressure in the tank is too high, report leak
 - If the rate of change is nominal, report no leak

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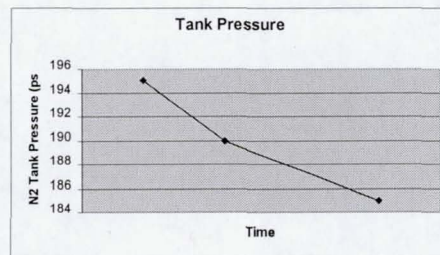
N2 Leak Test

- N2 Tank has been observed to refill several times in a 24 hour period
- Suspicion—the tank is leaking
- Test—refill tank and monitor loss of pressure
- Log rate of loss and time to reach milestone pressures

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N2 Leak Test Procedure

- Note time and tank pressure at start of test
- Note time when pressure reaches 190 psi. Calculate and record rate of loss.
- Note time when pressure reaches 185 psi. Calculate and record rate of loss.
End of test.



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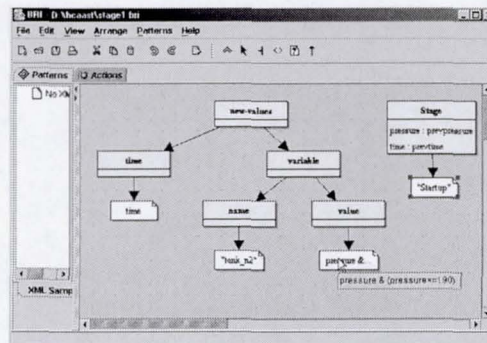
IBRA to track procedure

- One BRI for each data point
- BRI structure
 - Trigger: when pressure reaches designated point
 - Actions:
 - Calculate rate of change from previous pressure/time measurement (except the first BRI)
 - Record information as log entry in logger
 - Save pressure/time information for next calculation (except the last BRI)

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Review existing IBRA

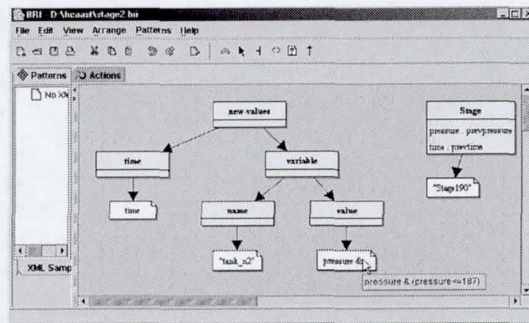
- View BRI in BRI Editor
- Decide to add another data point, at 187 PSI, for additional precision
- Create new BRI based on existing one



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Create New BRI

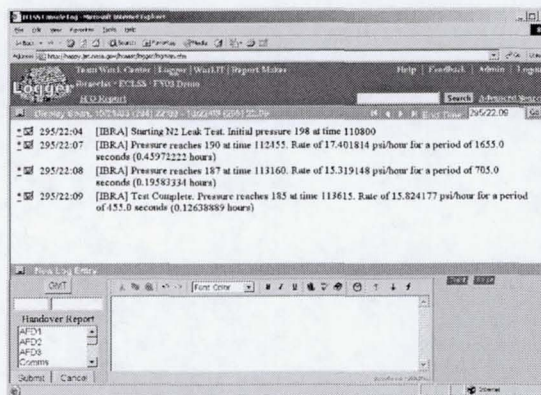
- View new BRI
- Load BRI into IBRA
- Start IBRA
- Perform procedure



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Review log at end of procedure

- Final report from the IBRA agent in the Logger
- Report saved for later reference
- Used as decision support



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BRI Editor Advantages

- Users can create additional IBRA capabilities without involving software developers
 - Adjust existing BRIs to fit changing needs
 - Add new ones (from scratch, copy and modify)
- Users can inspect existing existing BRIs to understand them better

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2. Human-Centered Methods

- Evolvable systems with “effortless specification”
- Requirements collection during prototyping

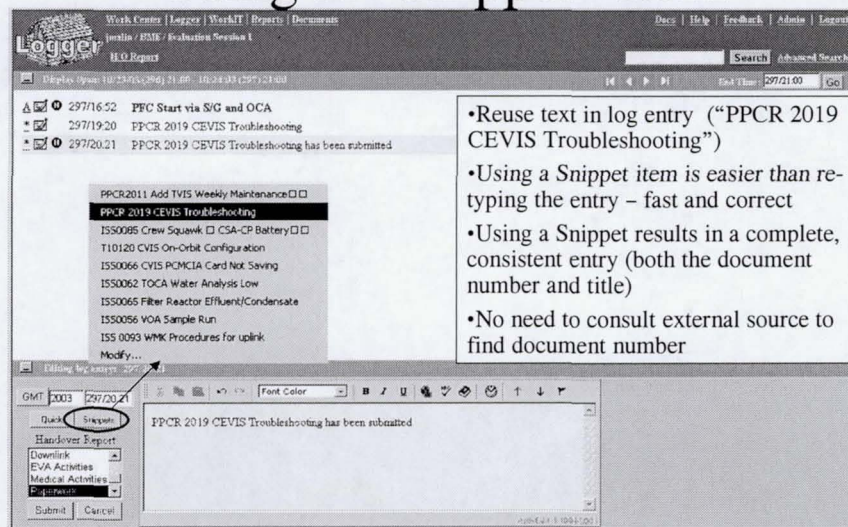
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Low Effort Specification

- Enabling evolution of sociotechnical systems
 - Users can customize software support
 - No need to go through formal software changes
 - Extends to unanticipated uses (as tasks change)
 - Extends to new groups of users
- Case
 - Logger: Snippets for common long text entries

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Using A “Snippet” Item



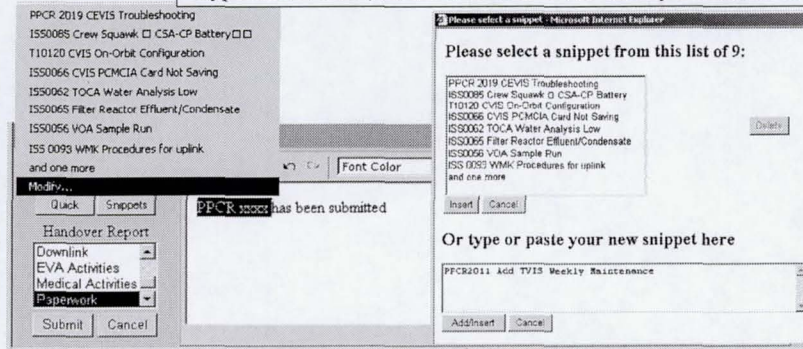
The screenshot shows the 'Logger' application interface. At the top, there's a navigation bar with links like 'Work Center', 'Logger', 'WorkIT', 'Reports', and 'Documents'. Below this is a search bar and a 'Go' button. The main area displays a list of log entries with timestamps and descriptions. A 'Snippets' window is open, showing a list of predefined text snippets. One snippet, 'PPCR 2019 CEVIS Troubleshooting', is selected. Below the snippets list, there's a text entry field where the selected snippet is being used. The entry text is 'PPCR 2019 CEVIS Troubleshooting has been submitted'. A 'Submit' button is visible at the bottom left of the entry field.

- Reuse text in log entry (“PPCR 2019 CEVIS Troubleshooting”)
- Using a Snippet item is easier than re-typing the entry – fast and correct
- Using a Snippet results in a complete, consistent entry (both the document number and title)
- No need to consult external source to find document number

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Adding A “Snippet” Item

- Highlight text to be replaced with Snippet string (“PPCR xxxx” from Quick menu entry, which attaches “paperwork” metadata)
- Click Snippet button
- Discover target text is not in list, decide to add it, select “Modify”
- Type in new text (“PPCR2011 Add TVIS weekly maintenance”)

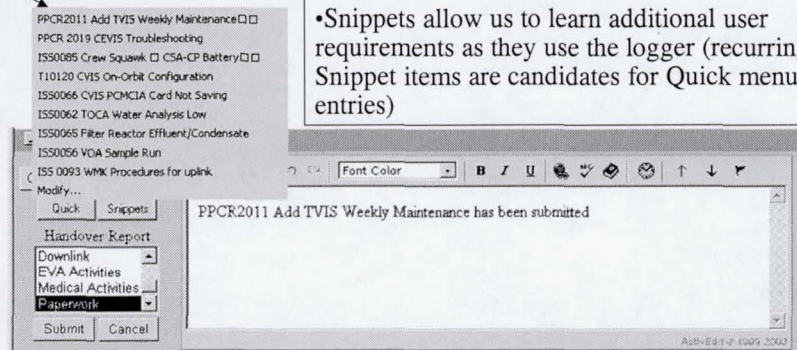


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Adding A “Snippet” Item: Benefits

- Adding a new Snippet is no more work than typing in log entry
- No new route is needed to add a Snippet (when user sees it isn't already on list, user selects “add new Snippet item”)
- Snippets allow us to learn additional user requirements as they use the logger (recurring Snippet items are candidates for Quick menu entries)

New entry placed at top of Snippet list



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Requirements from Prototyping

- Prototypes are developed to discover requirements
 - Inspection
 - Application itself is an inspectable artifact
 - Evaluation
 - Allows discovery of new requirements
 - Use
 - Prototype creates new requirements by changing work practice
- Prototypes are not mission-hardened
 - Inappropriate as product
 - Messy under the hood
 - “Layered” form evolution, and incomplete
 - Need to capture requirements in a document

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Requirements Benefits

- A Requirements Specification allows hand-off to production development team
- Some requirements cannot be implemented in current prototype due to early design choices
- Helps with transition to production and operations environment
- Aids identification and clarification of requirements which come out of prototype inspection

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Progress on WorkIT Requirements

- Analysis of design artifacts begun
- Specification format under development
 - Combining both high-level and “as-built” requirements
- Identification of requirements vs. design choices
 - Rationale capture by Design Team and developer
 - Non-implemented reqm'ts will be specified with less detail
- Will do example trace from design artifact to specification

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A Methodology for Generating Software Requirements from Prototyping: WorkIT Case

2 General Prototyping Approaches

- 2.1 Exploratory prototype
- 2.2 Experimental prototype
- 2.3 Evolutionary prototype
- 2.4 Prototype construction techniques

3 A Prototyping Case Study

- 3.1 Background
- 3.2 Early exploratory prototyping
- 3.3 Second prototyping iteration
- 3.4 Prototype evaluation
- 3.5 Expansion of customer base
- 3.6 Incremental development prototyping

4 Generating Requirements from Prototypes

- 4.1 Understanding the task
- 4.2 Basic functionality
- 4.3 Data model and user interface
- 4.4 Usability
- 4.5 Utilities
- 4.6 Look and feel

5 Artifacts of Prototyping

- 5.1 Mission operations documents
- 5.2 Walkthrough evaluations
- 5.3 Early requirements specification document
- 5.4 Hands-on evaluations
- 5.5 On-line feedback
- 5.6 Design team meetings
- 5.7 Design sketches
- 5.8 Requirements rationale

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Team Products and Requirements

- Implications for Design Team of need and designs
 - Products of design team needed for requirements
 - General guidelines as well as specific design and implementation
 - Interface, functional and back-end requirements
 - Team Products are Design Artifacts
 - Annotated Designs, Screen Shots
 - Alternative designs
 - Wish list for reimplementation is important source
 - Prototype as artifact
 - Rationale needed as prototype can't capture all requirements
 - Early design choices preclude implementation of some requirements

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3. Technology Infusion of Teamwork Tools

- Exploration Planning and Operations Center (ExPOC) use of WorkIT in NEEMO-5
- Preparation for operational evaluation of WorkIT version 4.0
- Logger evaluation
- Preparation for operational evaluation of Logger version 1.0

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WorkIT Evaluations

- BME walkthrough evaluation with some free use (videotaped) - WorkIT 2
- Stuffing the BME database with content from past issues (designers and feedback forms) – WorkIT 3
- ExPOC evaluation in training walkthrough for NEEMO-5 Mission (videotaped and feedback forms)
- ExPOC drop-in interview evaluation during NEEMO-5 Mission, June 2003
- BME evaluation in operational use– WorkIT 4 (Surgeon/BME in ISS Expedition 8)

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WorkIT in NEEMO-5



WorkIT support in NEEMO-5

- WorkIT prototype use and informal evaluation during the 6/03 NASA Extreme Environment Mission Operations (NEEMO-5) mission in ExPOC
 - NASA crew living in Aquarius Underwater Research Facility off the coast of Key Largo, Florida.
 - Practice for long-duration space habitation, research and construction, with undersea structures simulating Space Station assembly activities
- WorkIT tool provided information management and action tracking for the NEEMO topside operations teams at Johnson Space Center and in Florida
 - WorkIT was not specifically designed for this group of about 10 people
 - Primary use: Handling issues that involved assigning actions
- Evaluations
 - Videotaped training walkthrough that produced a wealth of feedback
 - Drop-in interviews and observations of three users during the mission
- Results
 - Surprised and delighted with automated services and low overhead
 - Found it intuitive and easy to use, even without using the tutorial
 - Found that it reduced rather than increased workload in handling actions
 - Eager to use during upcoming missions and to help prepare for missions

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WorkIT 4.0

- New capabilities
 - NOTE item for entering a text item without attached file
 - Automatic creation of Status Report
 - More comprehensive search that includes Task Logs
 - WorkIT tutorial and Help system framework
- Improvement in
 - Feedback system (from users to developers)
 - Navigation and UI presentation
 - Capacity for handling large status and task logs
 - Error handling
- Accommodation of new configuration in Surgeon/BME database and server platform

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Console Logger 1.0

- Logger Objectives
- Logger Features
- Example Views (Quick Entries, Searches, Reports)
- Evaluation
- Future Plans

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Logger Objectives

- Support console logging tasks
 - Assist entry of common log note types
 - Assist in making complete, consistent entries
 - Search log notes based on topic, author, activity, discipline
 - Make logs available to flight controllers not on console
- Support report generation from log notes
- Make logger accessible to other console support agents
 - Automated log notes from telemetry, ELog messages (IBRA)
 - Integration with WorkIT, ReportMaker

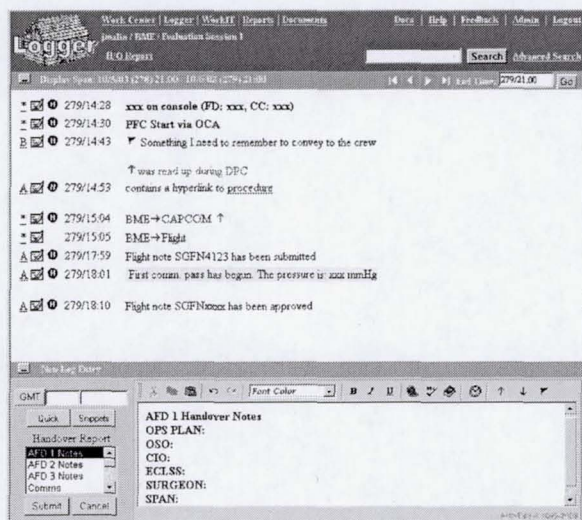
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Logger Prototype Features

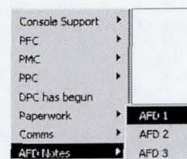
- Web based application (accessibility, user acceptance)
- Data base orientation
 - Each time-stamped entry is a separate record
 - Records organized by discipline and activity (flight increment, simulation)
 - Users can search entries by topic, author, discipline, activity
- ReportMaker integration
 - Selected log notes go to a specific part of the Handover Report, depending on the category assigned to them
 - Additional report types (Daily Summary) are definable
 - Reports are converted to Word format for printing
- Low effort entry for common types of log notes

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Assistance for Common Entry Types



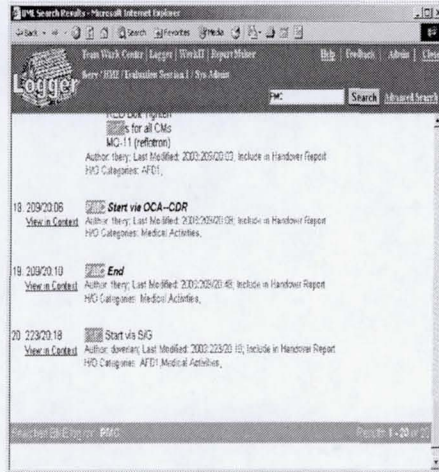
- Quick menu selection
- Auto text entry
- Auto handover category marking
- No need to enter timestamp unless different from now



Quick menu

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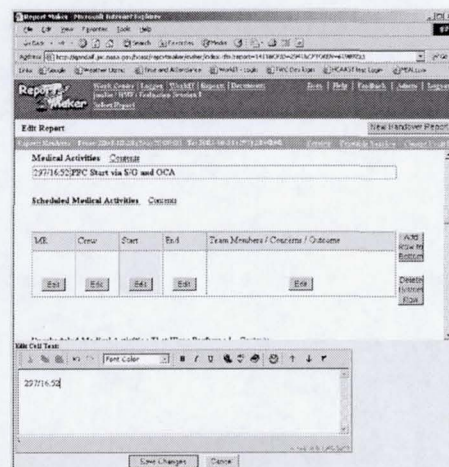
Logger Searches



- Basic search implemented
- Full info on “hits”
- Capability to view “hits” in context of other log notes on same shift
- Future: control search of time-frame, disciplines, activities; re-execute common searches

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Automated Reports



- Report format specifies log entry queries to include in Handover Report
- Specific text entry areas allow direct input into report
- Later, reports are printable in Word format

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Logger Prototype Evaluation

- Purpose: Formative rather than summative
 - Identify improvements needed in prototype
 - Not to compare performance to other software
- Method: Demonstration (with flight controllers exercising the logger functions) and Interview
- Evaluators: Four flight controllers
- Videotaped for subsequent analysis of specific features
 - Timing of system responsiveness
 - Reviewing for points where user interactions were difficult

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Logger Progress/Plans

- Enhancements
 - Quick menu: New entries with fill-in formats for console support and AFD notes; arrow icon; highlighting
 - Snippets: Re-implemented to fix persistent bugs
 - Handover Report: Refined format for Surgeon/BME
 - Dedicated server to ensure fast system response
 - Help pages
- Surgeon/BME evaluation in mission simulations soon
- ExPOC evaluation in undersea mission soon
- Longer Range
 - Multi-discipline views of logs (e.g front and back room)
 - User interface for customizing menus and report formats
 - IBRA-base automated logging of routine, telemetry-based entries
 - Assistance for tracking paperwork, to-do lists (make use of artifacts from users)

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4. Demonstrations

- Simulation testbed
- FY02 Demonstration
- FY03 Demonstration
- Integrated Demonstration support

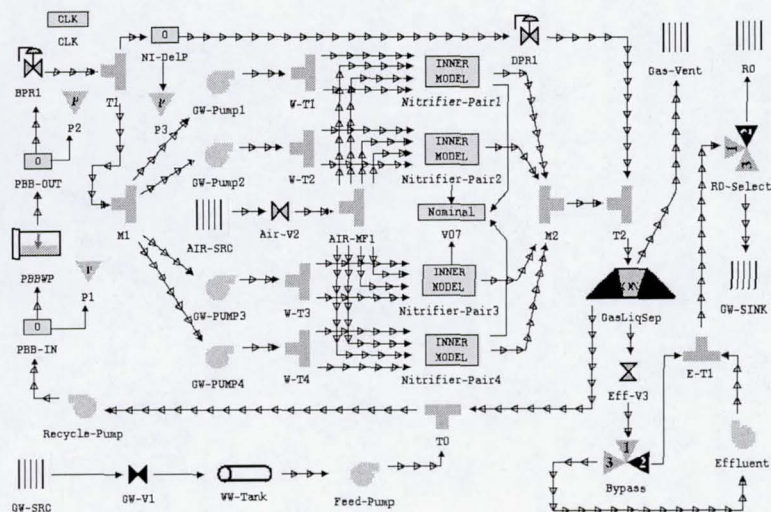
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Simulation Testbed

- Testbed simulates operation of life support system hardware (air and water systems)
 - Dynamically interacts with ISMAs, to test new ISMA capabilities in teamwork to intervene during anomalies
 - Capability to simulate combined, cascading and global effects of local problems
 - Case server (Java) utility saves and replays simulation cases
 - Capability to remotely pause and resume supports scripted dynamic interaction between ISMA and user in FY03 demo
- Enhanced biological water processor model will simulate more off-nominal scenarios
 - Uses generic library of components from Model-Based Hazard Analysis project (ECS program), to support broader variety of types of failures and degradations in system

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Model of Biological Water Processor



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Configurable Failable Components

- Styles of modeling failures and degradation
 - Discrete changes triggered by failures and problem inputs
 - Immediate or delayed changes to state, behavior mode or control regime
 - Continuous degradation triggered by failures and problem inputs
 - Nontemporal algebraic relations
 - Performance level affected by conditions
 - Failures to operate or change upon input: stuck flags
 - Random variation in measurement or input
- Degrading and regenerating processing performance
- Reactors and separators with multi-component mixtures
 - Add and remove contaminants in rapid fluid composition changes
 - Migrate products, gas or liquid to wrong outflow
 - Imbalance process with feed or flow reversal problems
- Resource providers with alternative methods for reacting to excessive demands from multiple loads
- Leaks as specifiable additions to simulation scenarios

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FY03 Demo

- ISMA autonomous control of air processing systems in space, with joint anomaly management
 - Mixed-initiative dialogue with ISMA to execute a leak test for Oxygen Generation System
 - Loose command and response leads to agreement on conditions and timing
- IBRA helps maintain situational awareness of system status and ISMA operations with manual intervention
 - Automatically carries out customizable instructions to collect and present information in web applications
 - Ground controllers easily specify and activate instructions
 - Leak Test Instructions - triggered act-whenever requests
 - Actions include Logging and Report on Leak Test timing and states
 - Start and complete conditions, test start and stop, level measures

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Demonstrated Benefits

- ISMA aids anomaly response and user intervention with mixed initiative dialogue
 - Basic support for moving from loose commanding to tight and complete plan
 - Supported by ISMA capabilities to delay and abort
- IBRA aids monitoring, logging and report generation for Leak Test intervention
- Tool suite provides basis for further teamwork on anomaly and knowledge capture
 - Reference materials and special and periodic reports
 - Searchable logs and action items with metadata
 - Customizable IBRA instructions

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Plans for FY04-05

- Continue process of spin off into mission operations
- Advance technology infusion (HCC) methods
 - Use of teamwork artifacts for prototyping and customizing
 - Requirements collection that influences prototyping methods
 - “Effortless specification” strategies for evolvable systems
- Advance collaborative agent capabilities
 - Mixed-initiative interaction for joint problem solving and command completion.
 - Safety conscious agents that use simulation for checking response plans and resuming interrupted operations

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